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Winn et al.

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(54) **DEVICES, SYSTEMS AND METHODS RELATING TO DOWN HOLE OPERATIONS**

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This patent is subject to a terminal disclaimer.

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(65) **Prior Publication Data**

US 2013/0192818 A1 Aug. 1, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/423,802, filed on Apr. 14, 2009, now Pat. No. 8,356,662.

(51) **Int. Cl.**
E21B 37/02 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 37/02*** (2013.01)

(58) **Field of Classification Search**
USPC 166/311, 312, 170, 171, 173, 174
See application file for complete search history.

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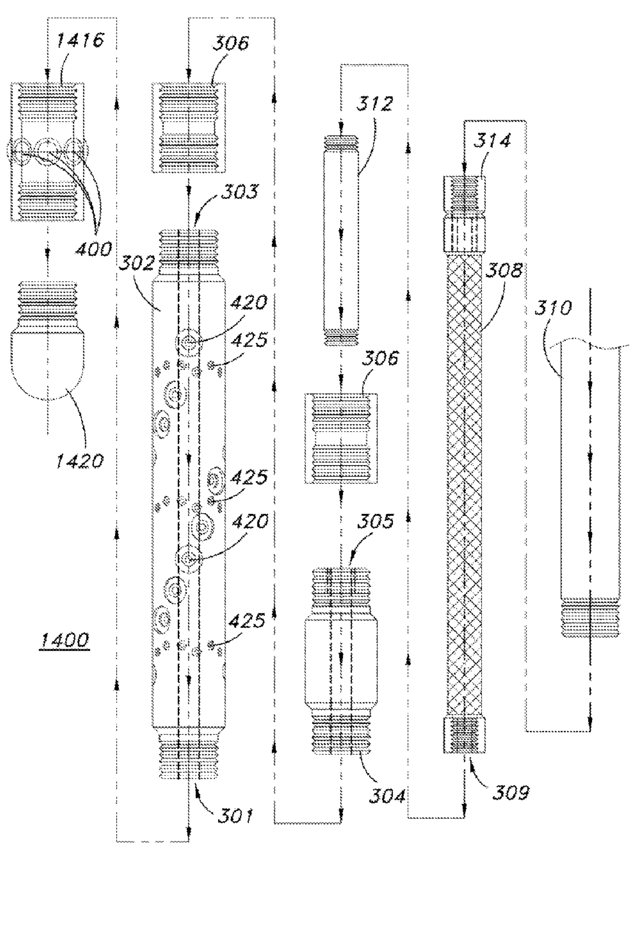
Primary Examiner — William P Neuder
(74) *Attorney, Agent, or Firm* — Jones IP Group

(57) **ABSTRACT**

Systems and method for improving down hole operations of well casings are disclosed herein. Systems and methods disclosed herein can comprise brushes, high pressure fluid outlets, and skids. Other systems and methods are disclosed herein.

17 Claims, 16 Drawing Sheets



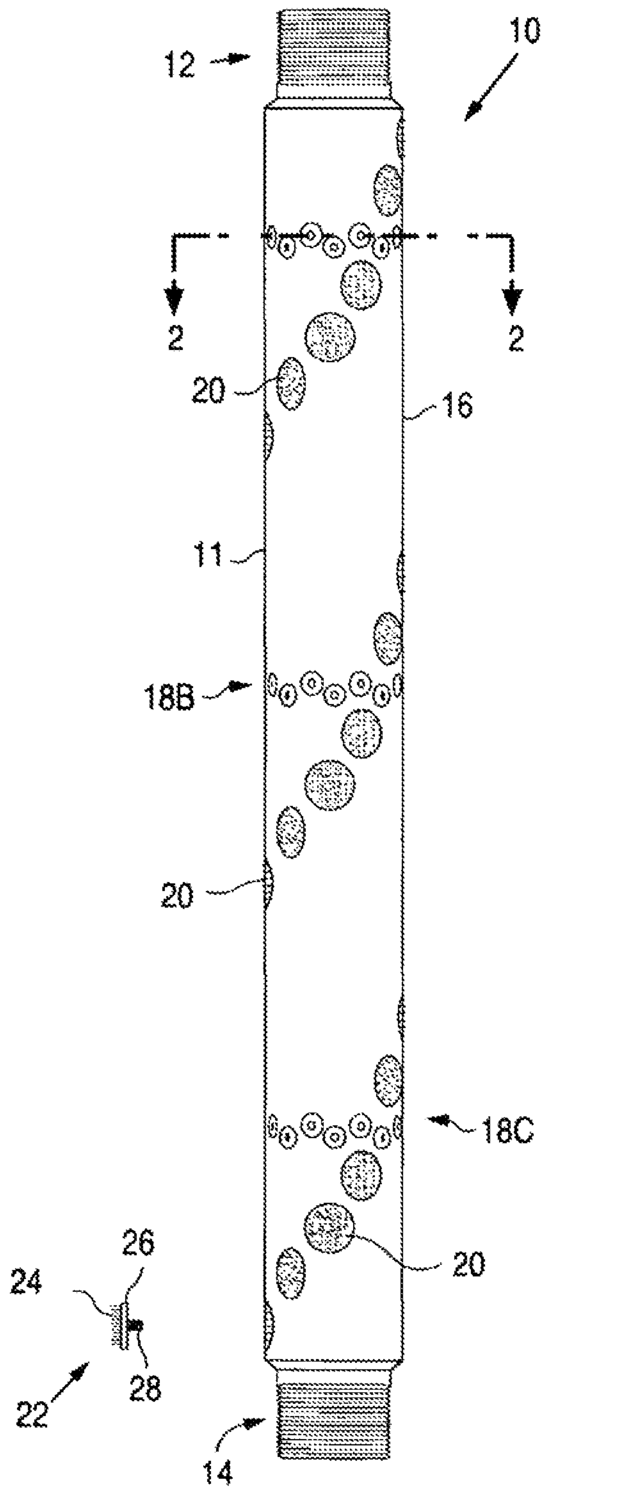


FIG. 1

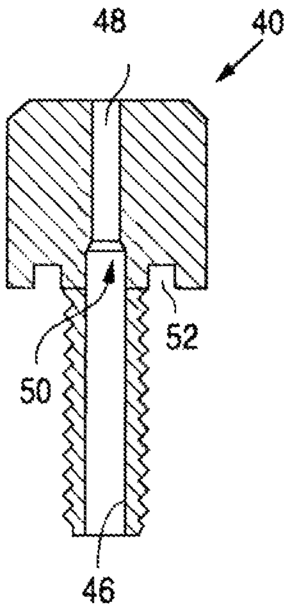


FIG. 2A

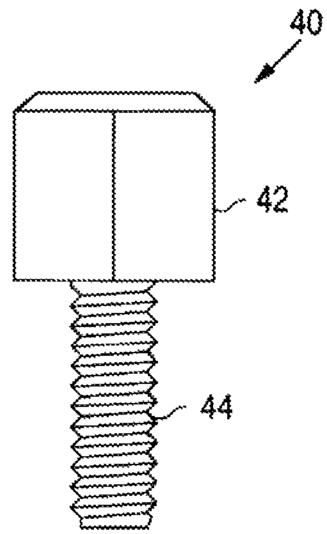


FIG. 2B

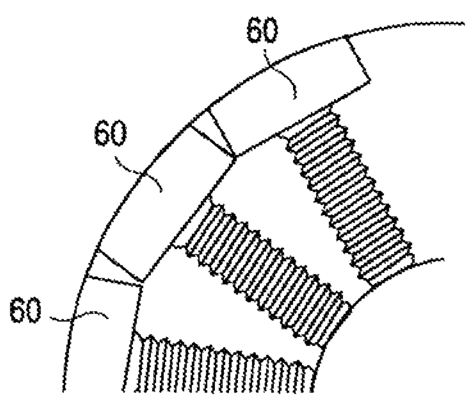


FIG. 3

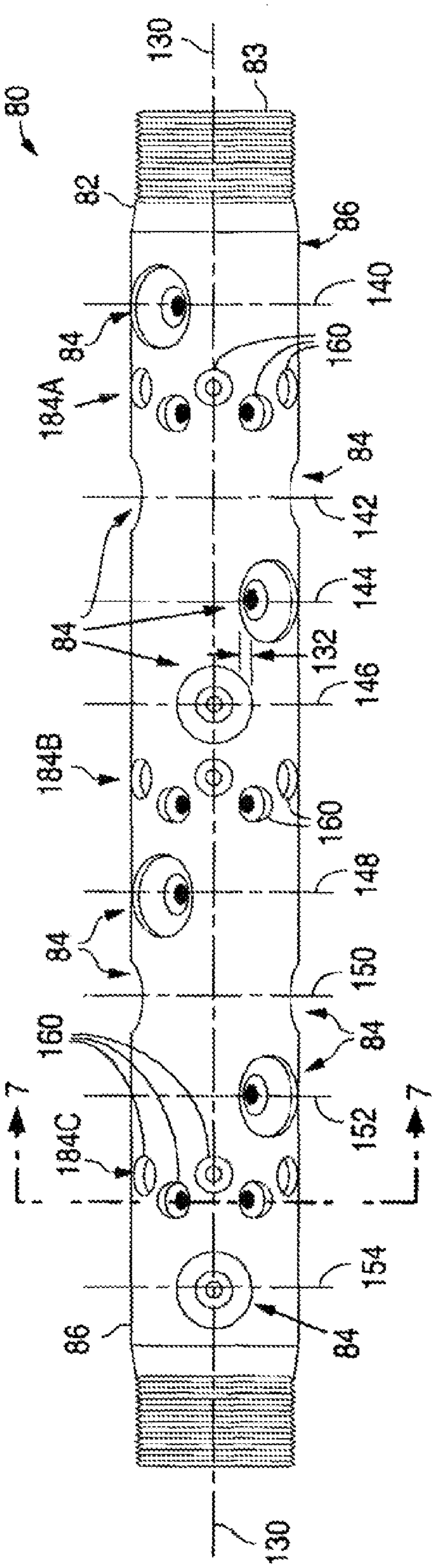


FIG. 4

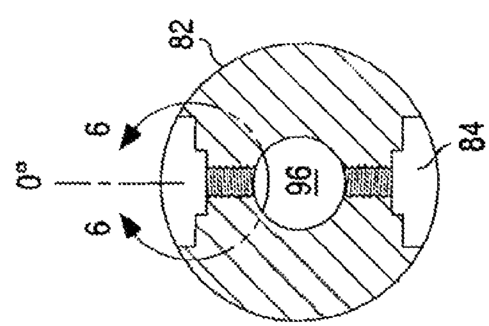


FIG. 5A

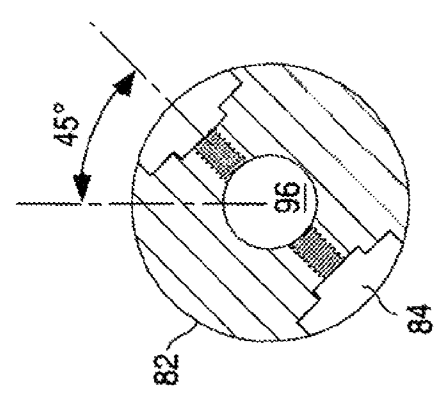


FIG. 5B

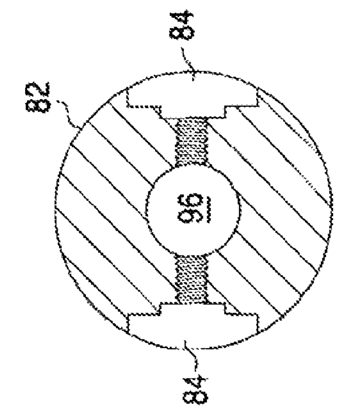


FIG. 5C

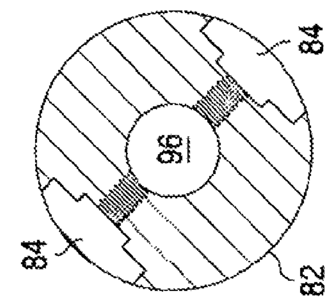


FIG. 5D

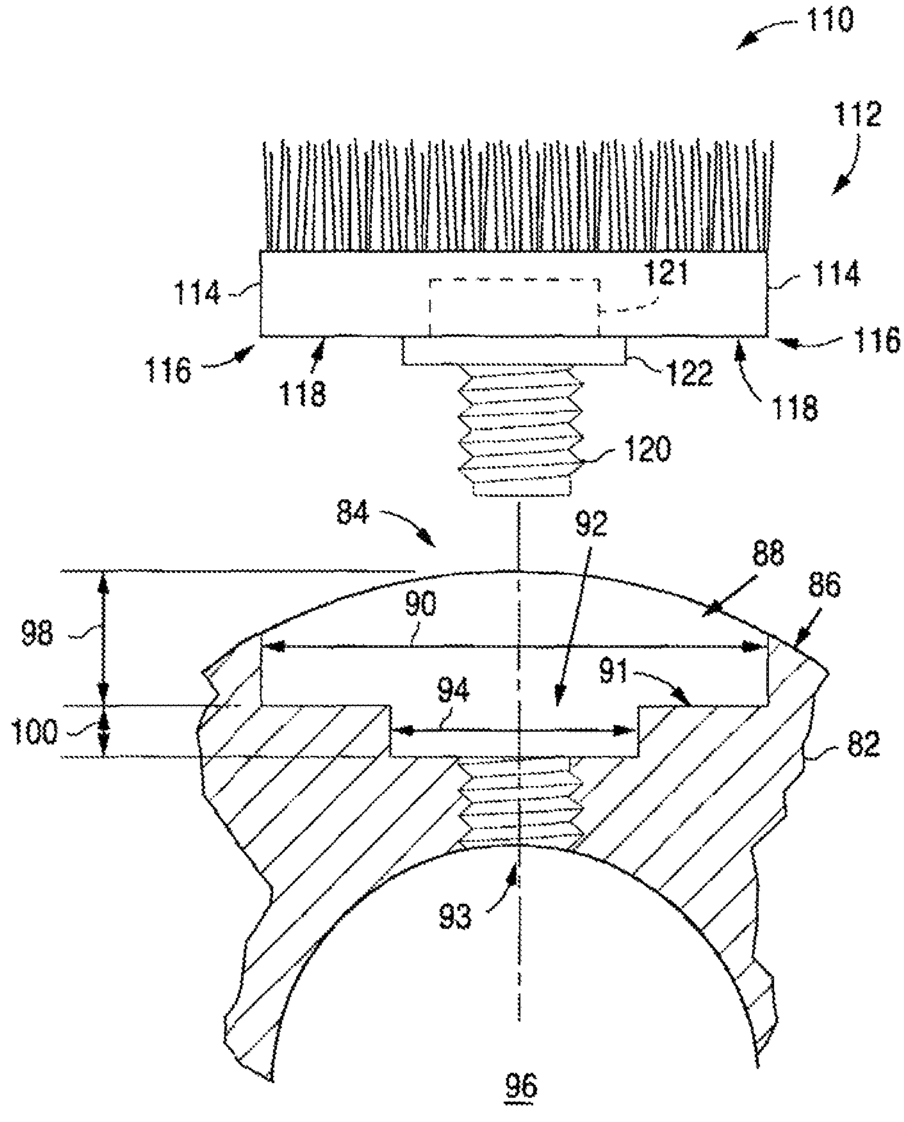

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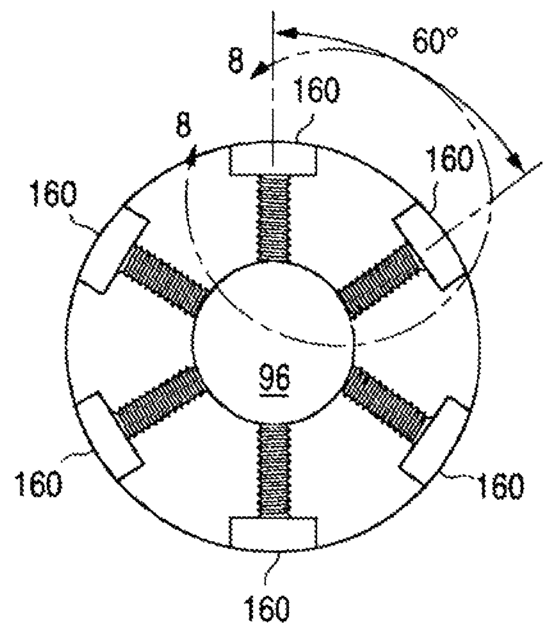
FIG. 6



60°
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160
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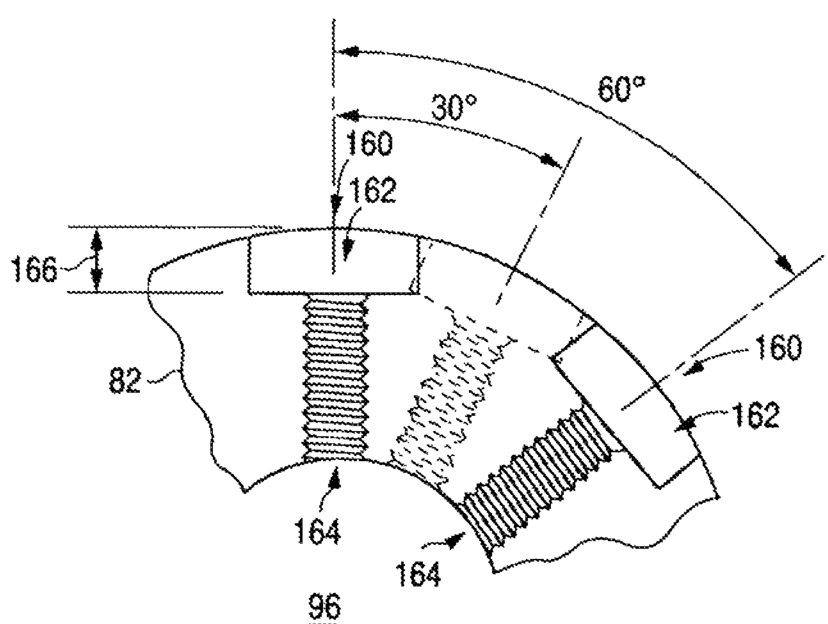
160

FIG. 7



60°
30°
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164
164
96

FIG. 8

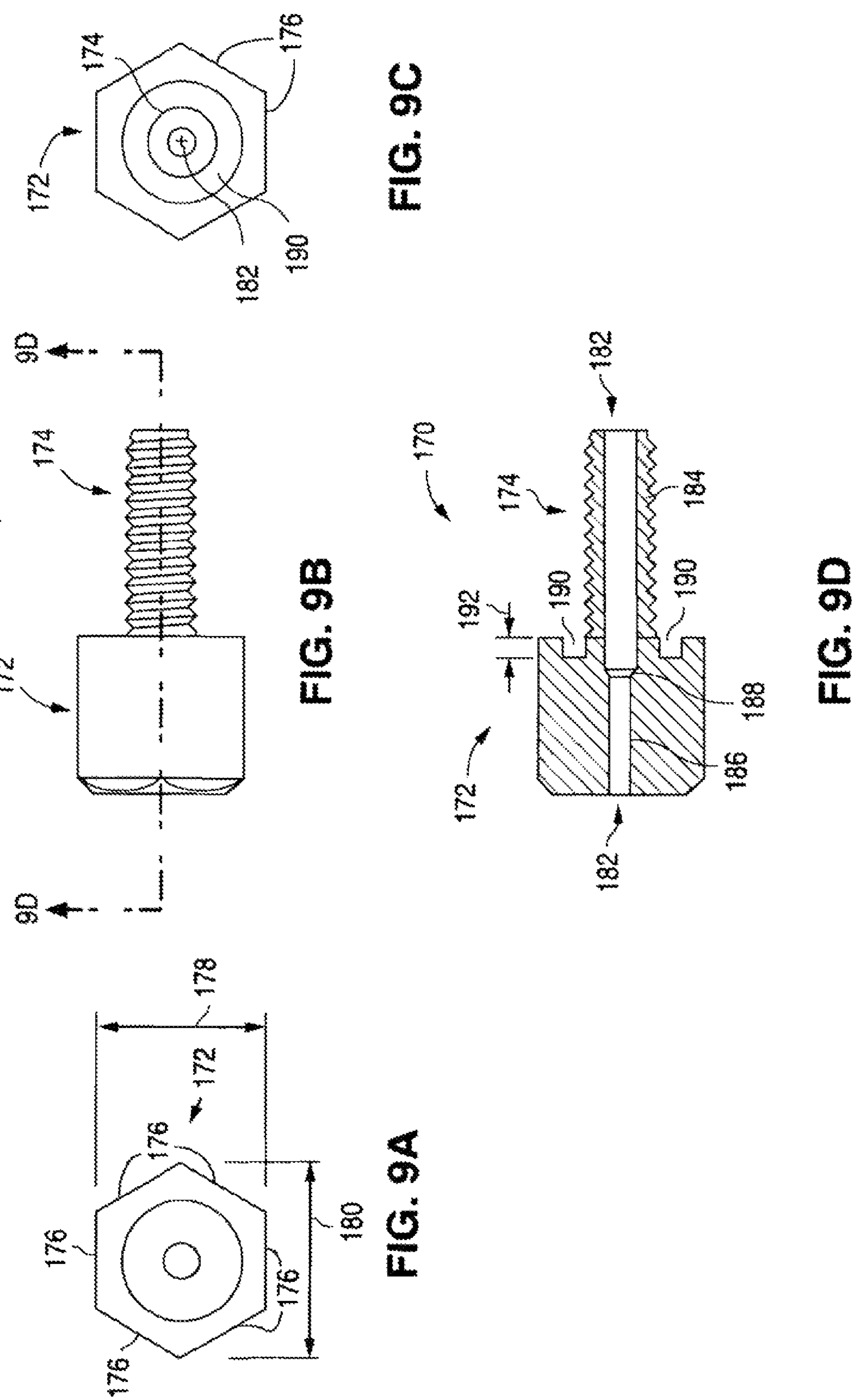

FIG. 9C

FIG. 9B

FIG. 9D

FIG. 9A

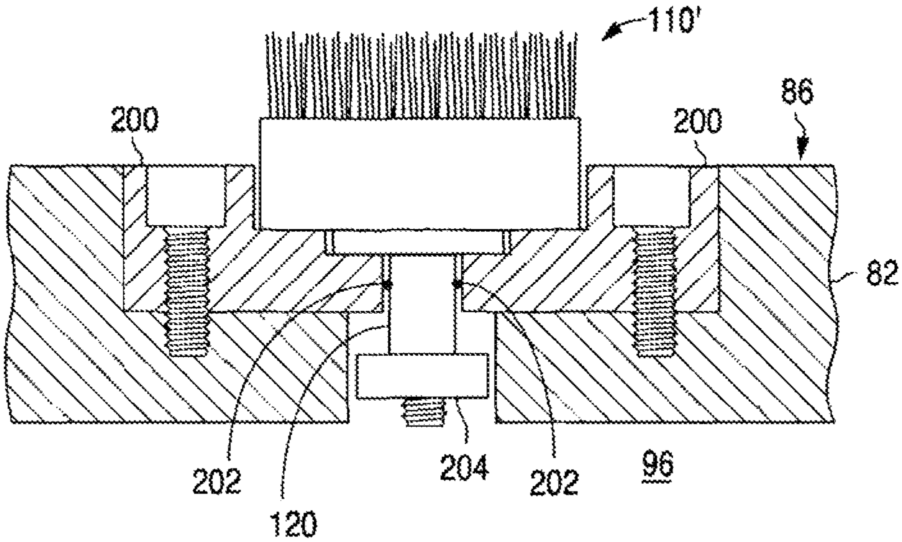

FIG. 10A

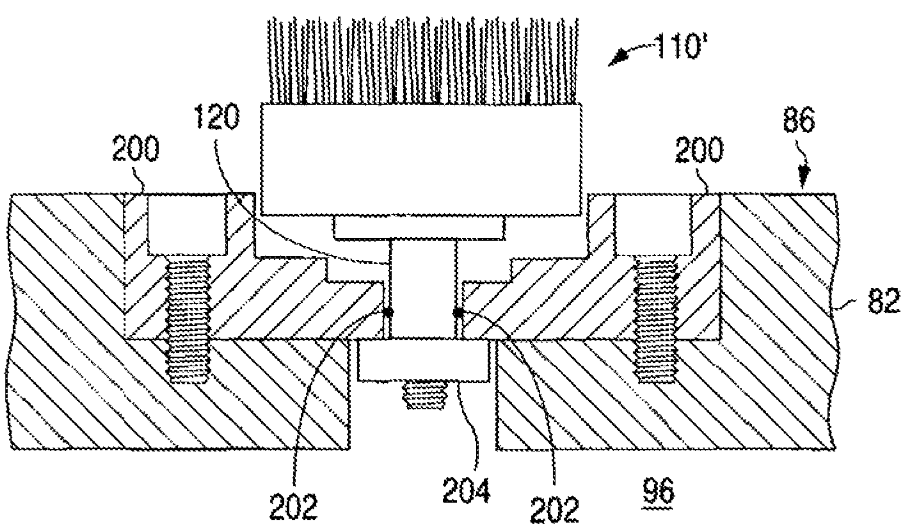

FIG. 10B

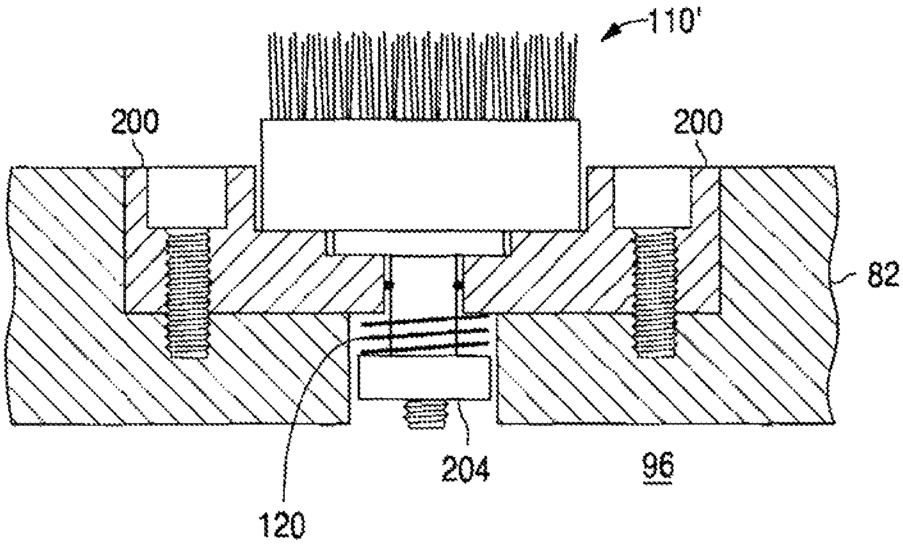

FIG. 10C

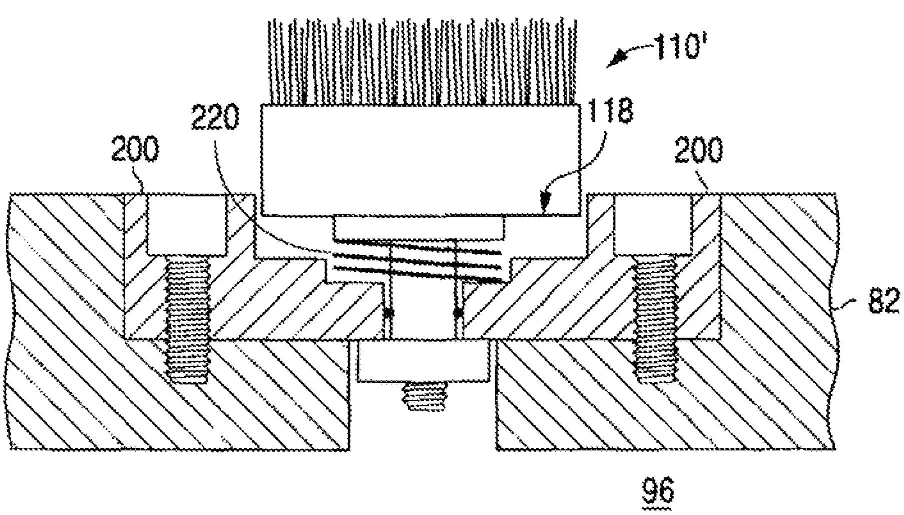

FIG. 10D

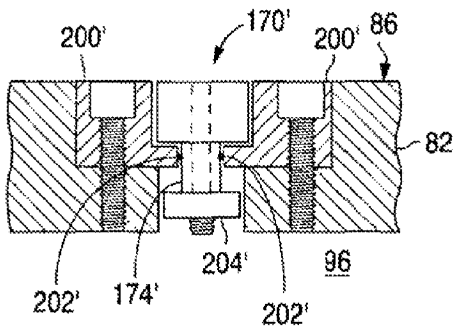

FIG. 11A

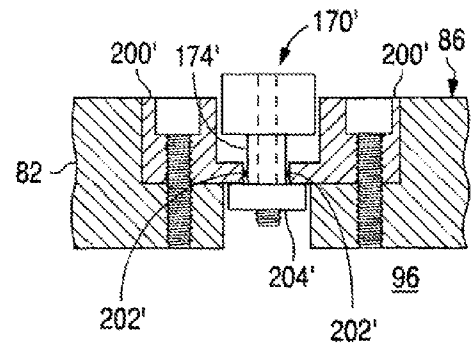

FIG. 11B

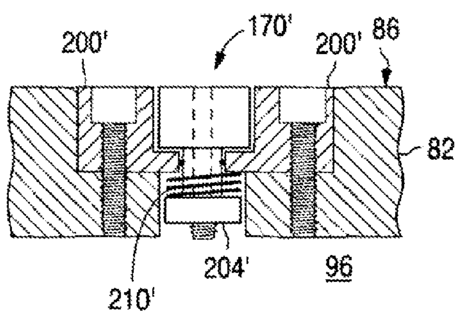

FIG. 11C

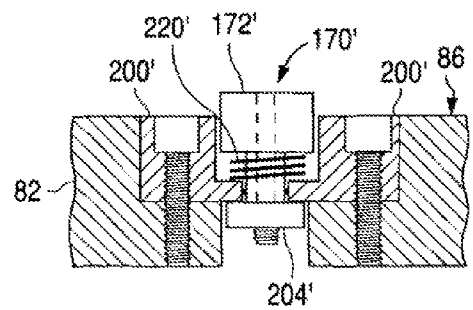

FIG. 11D

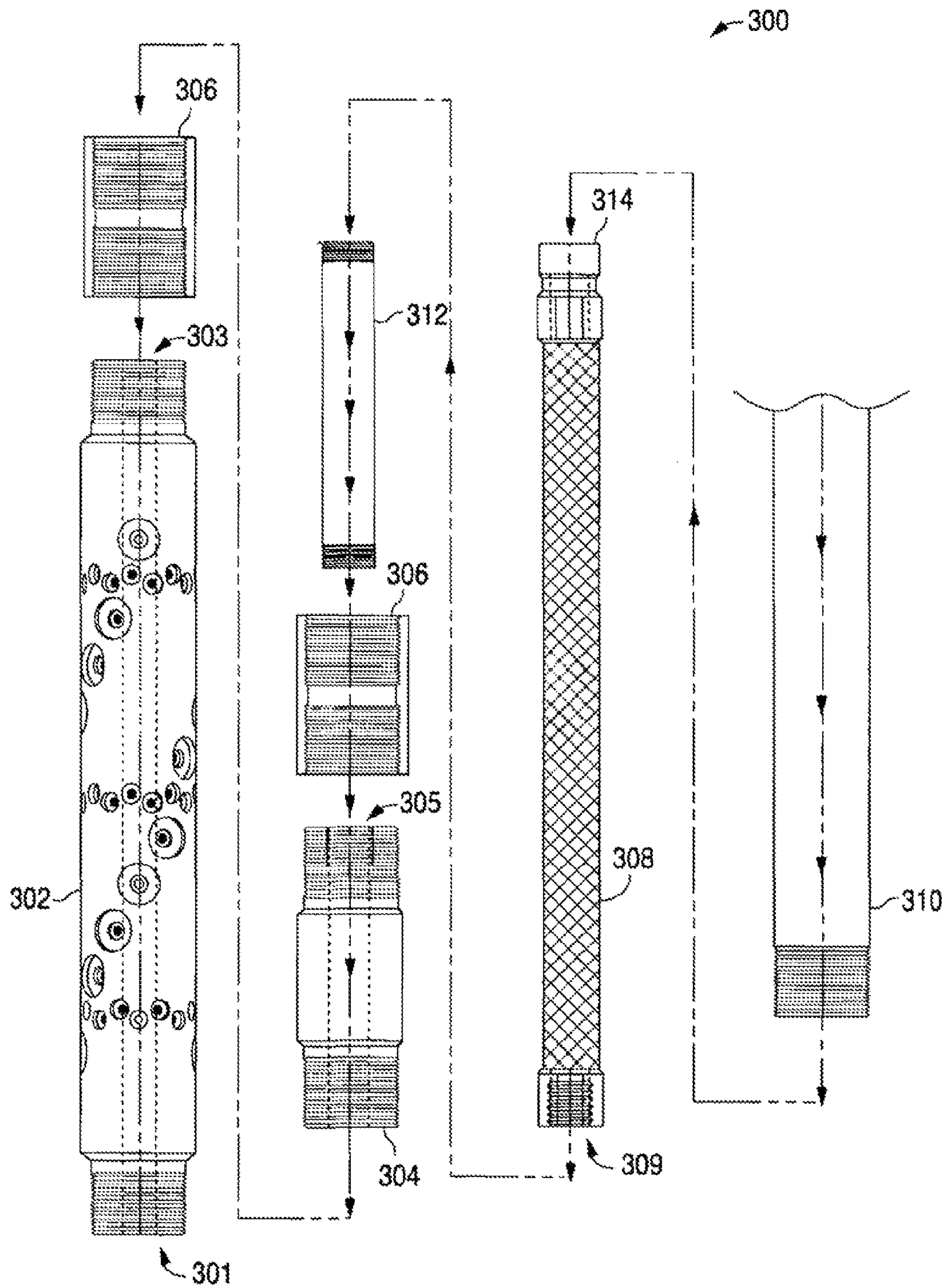

FIG. 12

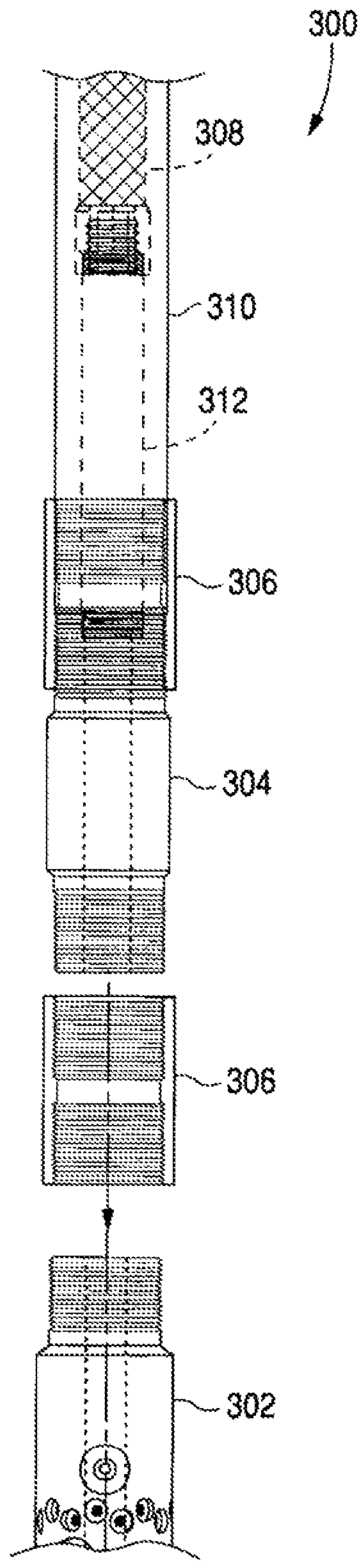

FIG. 13

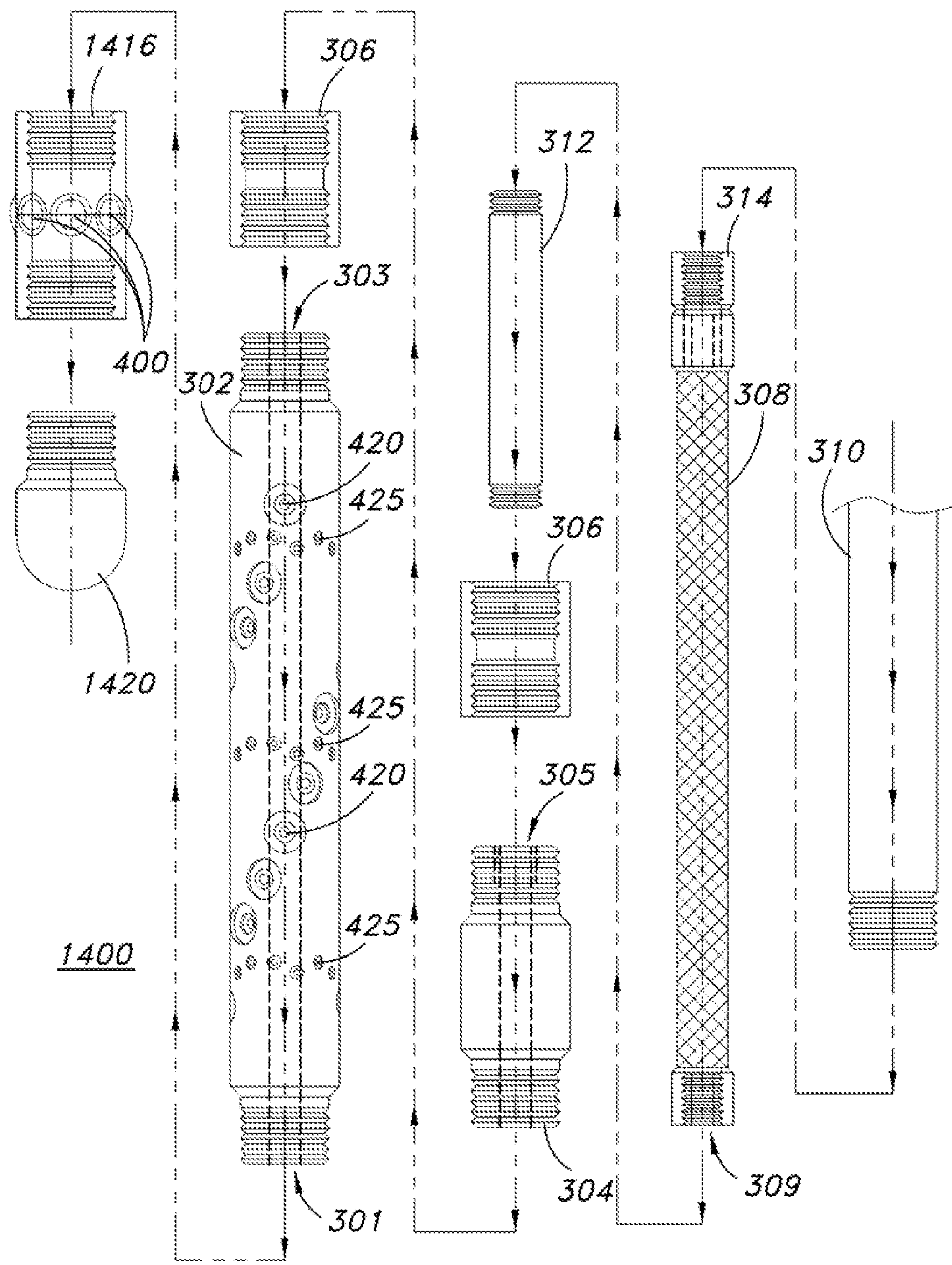
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FIG. 14

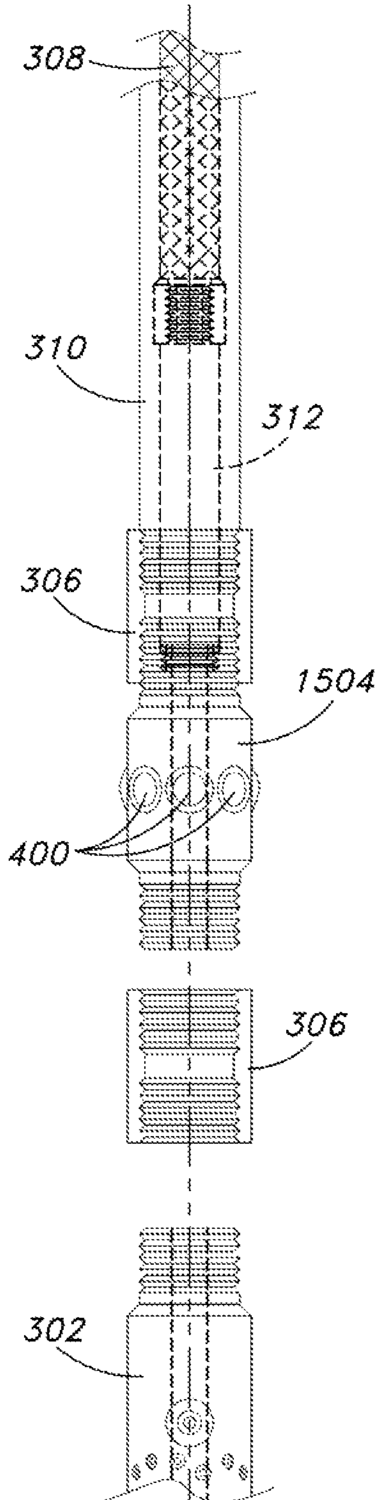

FIG. 15

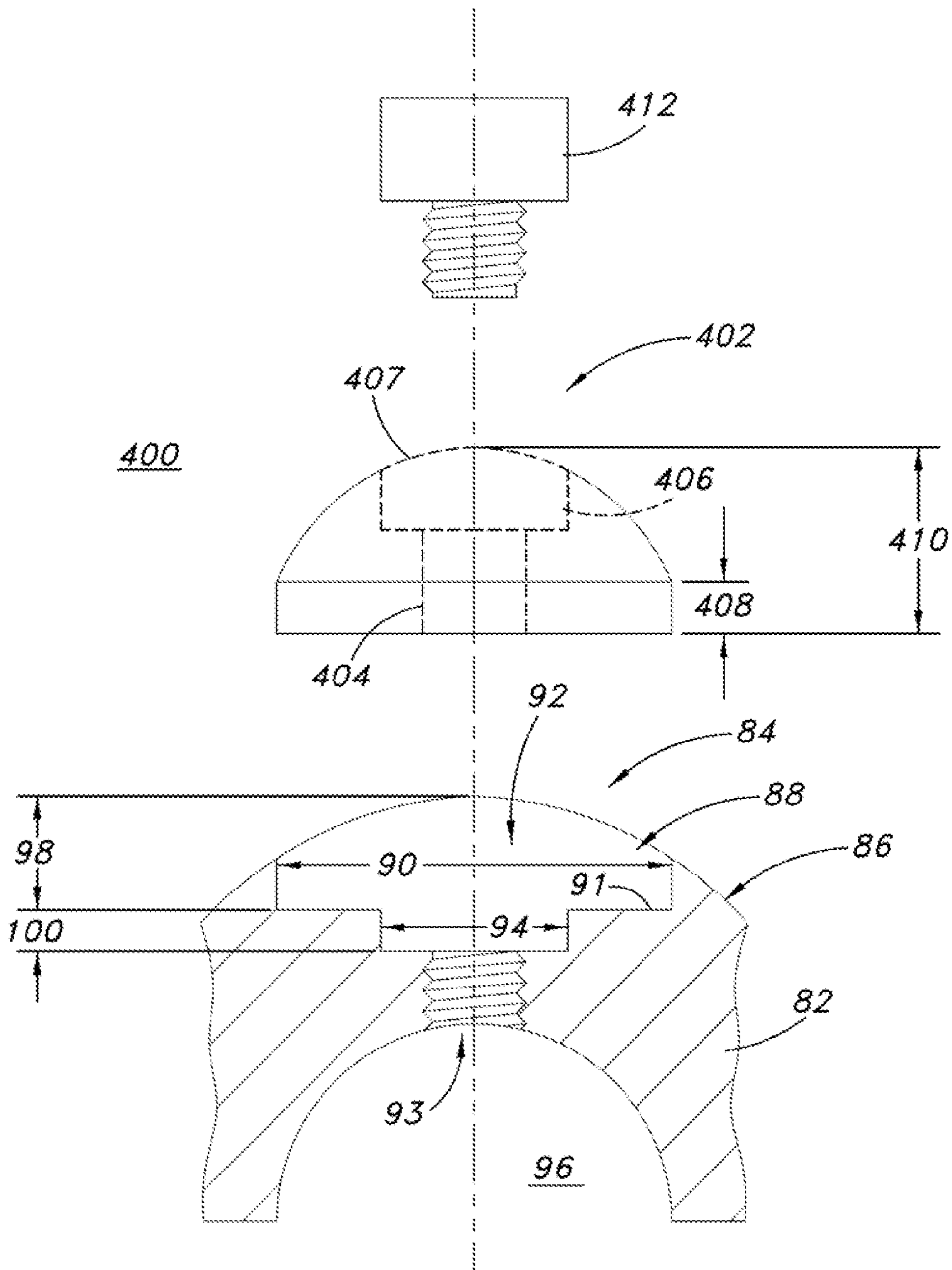

FIG. 16

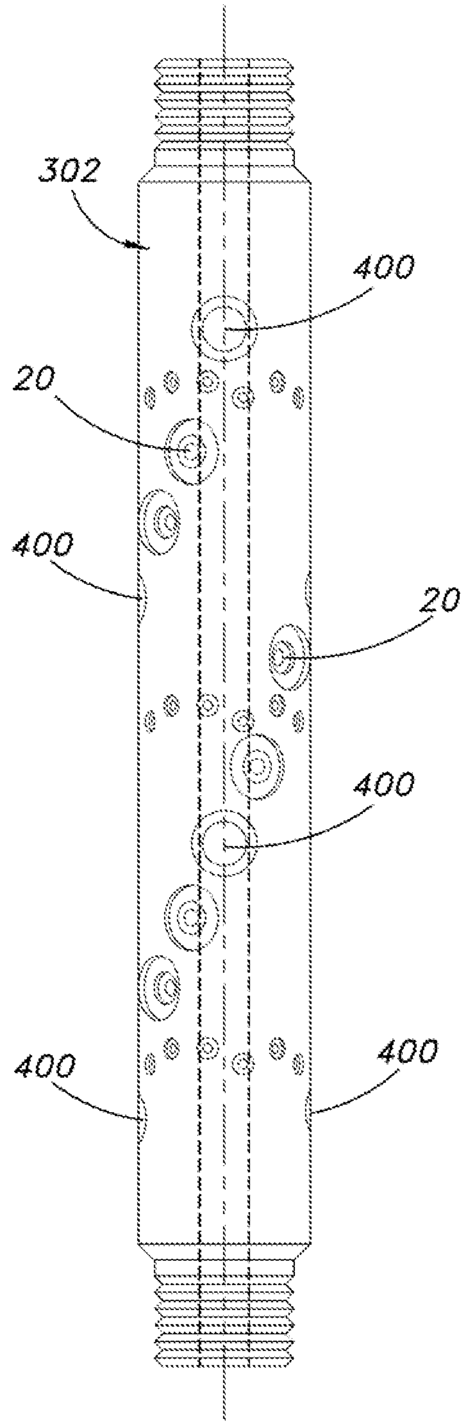

FIG. 17

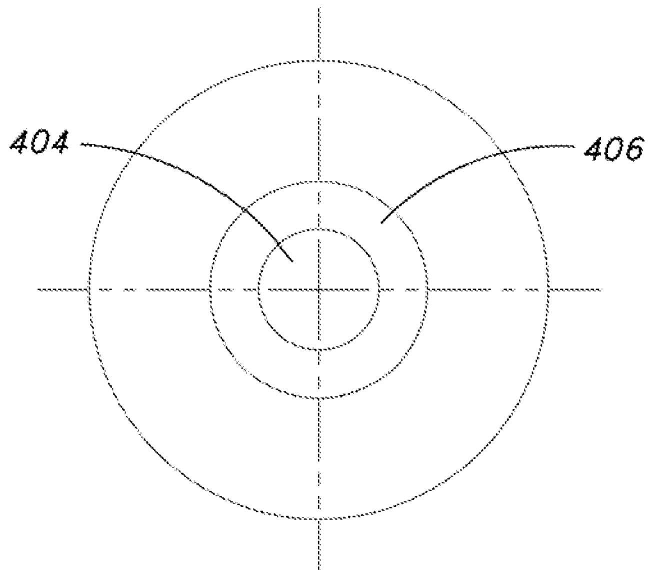

FIG. 18

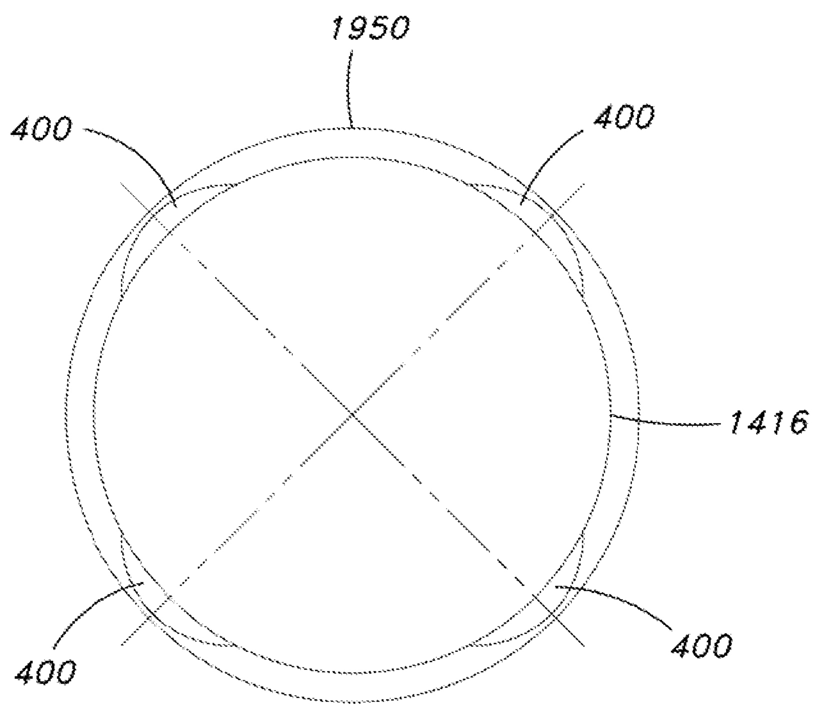

FIG. 19

DEVICES, SYSTEMS AND METHODS RELATING TO DOWN HOLE OPERATIONS

RELATED APPLICATION(S)

The present application is a continuation-in-part of U.S. patent application Ser. No. 12/423,802, filed Apr. 14, 2009, entitled "DEVICES, SYSTEMS AND METHODS RELATING TO DOWN HOLE OPERATIONS," which claims the benefit of U.S. Provisional Application No. 61/044,675, filed Apr. 14, 2008, and U.S. Provisional Application No. 61/044,667, filed Apr. 14, 2008, all of which are incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

This invention relates generally to devices, systems and methods relating to improved down hole operations and, more particularly, to devices, systems and methods for enhance the recovery of hydrocarbon liquids and gases from down hole environments.

BACKGROUND OF THE INVENTION

The amount of oil and/or gas that a well produces often reduces significantly over time. The reduction is often caused by clogged or obstructed perforations in the well casing at the production area and the accumulation of wax, scale, or other residue on the inside of the casing of the well. Prior art methods for removing such debris and clearing the well casing perforations often require multiple tools, are inefficient and time consuming. Prior art methods and devices also may tend to alter ground formation permeability and may not allow for immediate bore cleanup without damage to the ground formation. Accordingly, there is a need for a method, system and device that provides for an efficient, cost-effective means to improve down hole operations.

SUMMARY OF THE INVENTION

Certain embodiments of the present invention generally relate to devices, systems and methods relating to improved down hole operations. Embodiments of the present invention may be used to enhance the recovery of hydrocarbon liquids and gases from down hole environments. Embodiments may comprise an assembly attachable to a work string, with the assembly further comprising a plurality of directed fluid jets, brushes and or scrapers. Embodiments may comprise methods of using the assembly to enhance down hole operations or production.

In aspects of the present invention, a device for improving pumping operations through a casing or lining comprises a hollow tube including a tube wall having an outer circumferential surface and an inner circumferential surface, the inner circumferential surface defining a fluid passageway. The device further includes brushes on the outer circumferential surface, and outlet holes formed through the tube wall.

In aspects of the present invention, a system for improving pumping operations through a well casing or lining comprises a hollow scratcher tube including a tube wall having an outer circumferential surface and an inner circumferential surface, the inner circumferential surface defining a fluid passageway having a fluid inlet at one end of the scratcher tube. The system further comprises a plurality of bristles on the outer circumferential surface, a plurality fluid outlets formed through the tube wall, and a filter coupled to the fluid inlet.

In aspects of the present invention, a method for improving down hole operations includes inserting a scratcher tube into a curved casing string, the hollow scratcher including a tube wall having an outer circumferential surface carrying a plurality of brushes and a plurality of nozzles. The method further includes retracting at least one of the plurality of brushes or at least one of the plurality of nozzles to facilitate passage of the scratcher tube past a curved segment of the casing string.

The features and advantages of the invention will be more readily understood from the following detailed description which should be read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side elevation view of an assembly for improving down hole operations, showing a main body having a plurality of nozzle assemblies and brush assemblies.

FIG. **2**A is a cross sectional view of a nozzle assembly.

FIG. **2**B is a side elevation view of the nozzle assembly of FIG. **2**A.

FIG. **3** is a cross sectional view of a portion the main body of FIG. **1**, showing staggered insets **60** for receiving the nozzle assembly of FIGS. **2**A and **2**B.

FIG. **4** is a side view of an assembly for improving down hole operations, showing a plurality of outlet holes and inset portions for securing nozzles and brushes.

FIGS. **5**A-**5**D are cross sectional views of the assembly of FIG. **4**, showing various angular positions of inset portions for securing brushes.

FIG. **6** is a cross sectional detailed view of a portion of FIG. **5**A, showing an inset portion and a correspondingly shaped brush assembly adapted to be secured into the inset portion.

FIG. **7** is a cross sectional view of the assembly of FIG. **4**, showing various angular positions of outlet holes for securing nozzles.

FIG. **8** is a cross-sectional detailed view of a portion of FIG. **7**.

FIGS. **9**A-**9**D show a top view, side view, bottom view, and cross-section view, respectively, of a nozzle.

FIGS. **10**A-**10**D are cross-sectional views of piston-type assemblies adapted to allow radial movement of a brush assembly.

FIGS. **11**A-**11**D are cross-sectional views of piston-type assemblies adapted to allow radial movement of a nozzle

FIG. **12** is an side elevation view of a system for improving down hole operations, showing the system in a disassembled state.

FIG. **13** is a side elevation view of the system of FIG. **12**, showing the system in a partially assembled state with a scratcher tube removed from the rest of the system.

FIG. **14** illustrates an example of side elevation view of a system for improving down hole operations, showing the system in a disassembled state.

FIG. **15** illustrates an example of a side elevation view of the system of FIG. **14**, showing the system in a partially assembled.

FIG. **16** illustrates an example of a skid assembly.

FIG. **17** illustrates an example of a hollow scratcher tube according.

FIG. **18** illustrates an example of a cross sectional view of a skid assembly.

FIG. **19** illustrates an example of a cross sectional view of a guide piece.

DETAILED DESCRIPTION

Some embodiments of the present invention may comprise an assembly having a generally tubular shape and having a diameter appropriately sized to be inserted into the casing or well lining of a well, including in some instances an oil or gas production well. In some embodiments of the present invention the assembly may further comprise pressure jets, nozzles, and or orifices, brushes, and or scrapers. The assembly may comprise attachment configurations on an upper and lower portion of the assembly. The attachment configurations may facilitate attachment of the upper end of the assembly to a work string, sucker or other assembly. The attachment configurations may also facilitate attachment of the lower end of the assembly to other devices such as scrapers, filters, baskets or other devices.

In some embodiments the present invention is used to improve the flow of fluids, such as petrochemicals, or gases, through perforations or holes in the casing of an oil or gas well. In some embodiments of the present invention the flow of fluids or gases through the formations adjacent the perforations or holes in the casing may also be improved.

Over the course of production of fluids or gases from a well there may typically be a buildup of paraffin, wax, scale, or other residue on the inside of the casing of the well. In some instances the perforations or other slots or openings on the casing become clogged to some degree. Additionally spaces in the geological formations adjacent the casing may also become clogged to some degree. Each of these conditions may tend to inhibit the flow of desired gases or fluids from the geological formation through the slots or perforations and into the casing of the well where it can be extracted from the well. Aspects of the present invention are particularly useful in cleaning the inside environment of the casing, of opening the perforations or slots extending through the casing and further, in opening portions of the geological formations adjacent the casing to further facilitate the flow of gases or liquids.

FIG. **1** shows an embodiment of the present invention. Shown is an assembly **10** having an upper threaded portion **12** and a lower threaded portion **14**. Further shown in the assembly of FIG. **1** are three rings of nozzles (or high-pressure jets) **18** (shown at **18**A, **18**B and **18**C). Also shown in FIG. **1** is a spiraling array of brush assemblies **20**. An individual brush assembly is shown at **22** having brush fibers **24**, fiber assembly holder **26**, and threaded portion **28**.

The assembly **10** may comprise a pipe like main body **11** having an outer diameter and an inner diameter.

Main body **11** may have an inset portion for receiving the fiber assembly holder **26** of the individual brush assembly **22**. Further the inset portion they also comprise a receiver for receiving the threaded portion **28** of the brush assembly **22**. In some embodiments, the fiber assembly holder **26** does not extend out past the general exterior wall of the main body **11**. Instead, the brush fibers **24** extend radially out past the general exterior wall of the main body in **11**. The inset portions for receiving the fiber assembly, in some embodiments, may be spiraled vertically about the main body **11** as shown in FIG. **1**. Such an arrangement allows for the overlap of the individual brushes of the brush assemblies **22** with the brushes of adjacent assemblies.

Main body **11** may also include inset portions for receiving individual nozzles or high-pressure jets indicated at **18** and further illustrated in FIGS. **2** and **3**. In some embodiments the inset portions for the individual nozzles are distributed around the circumference of the main body **11** as shown at **18**. In some embodiments the distribution of the inset portions for the nozzles may be staggered vertically as shown in FIG. **1** at **18**. This staggering of the inset portions provides several advantages. One advantage is that it allows the nozzles to be spaced circumferentially about the main body **11** with smaller angles separating a first nozzle from an adjacent nozzle while still providing high structural integrity and strength to the main body **11**. In addition, as shown at FIG. **3**, the individual insets may be so closely spaced that, as shown in FIG. **3**, when viewed in cross-section the insets may appear to overlap with each other. By staggering the insets, this small rotational angle between the direction of adjacent nozzles can be achieved without deleteriously diminishing the structural integrity of the main body **11**.

In some embodiments the assembly **10** is connected by upper threaded portion **12** to a working string and lowered to the production zone of a well. The assembly **10** can be raised and lowered by the working string to effect a beneficial interaction between the inside of the casing of the well and the brush assemblies **20** of the assembly **10**. The brush assemblies can be configured in some embodiments to provide forceful brush contact simultaneously around the interior circumference of the casing as the assembly **10** is raised and lowered through the production zone of the casing. The brush assemblies **20**, then, "scrub" the interior portions of the casing in the production zone. Such scrubbing is useful in removing undesirable materials from the inside of the casing and the perforations or slots in the casing.

In some embodiments, simultaneously with the raising and lowering of the assembly **10** through the production zone of the well, high-pressure fluids are pumped through the work string into the top portion of the assembly **10**. In some embodiments, the assembly **10** will have a cap or similar structure attached to the bottom threads **14** prohibiting the exit of high-pressure fluids through the bottom portion of the assembly **10**. The high-pressure fluid will then exit the individual nozzles **18** of the assembly producing a highly desirable scouring effect on the interior portions of the casing as well as in the perforations and slots of the casing. The high-pressure flows of the fluid can also extend into the geological formations adjacent the casing thus opening improved opportunities for the flow of gas or fluid through the geological formations.

Because of the overlap of the brush assemblies **20** when the assembly **10** is raised and lowered through the casing, the entire periphery of the casing is scrubbed by the brushes. The assembly **10** can include a number of brushes including one to four (or more) sets the brushes covering 360° of the exterior of the assembly **10**.

Shown in FIG. **1** are three arrays of nozzles, **18**A, **18**B and **18**C, in some embodiments a greater or lesser number of arrays of nozzles can also be used.

FIG. **2** shows two views of an exemplary nozzle assembly **40**. FIG. **2**B shows a plain view of the nozzle assembly **40** having a hexagonal or orthogonal head portion **42** and a threaded portion **44**. FIG. **2**A shows a cutaway view of the nozzle assembly **40** of FIG. **2**B.

Shown in FIG. **2**A is a fluid passageway comprising three sections: large diameter section **46**, step down section **50**, and small diameter section **48**. Also shown is an O-ring receiver portion **52**. The nozzle assembly **40** can be assembled into an appropriately sized inset in the main body **11**. The threaded portion **44** will mate with a threaded receiver in the main body **11**. The main body inset for the nozzle **40** can also comprise a receiver surface for receiving the O-ring (not shown) to be an attached in O-ring receiver portion **52**. The small diameter section **48** of the fluid passageway can be of varying lengths, including significantly shorter than the large diameter portion **46**. With this configuration the flow of high-pressure fluids through the nozzle assembly **40** is significantly facilitated, allowing a greater flow of fluid through the nozzle assembly **40** and reducing the energy loss of forcing the fluid through the fluid passageway of the nozzle assembly **40**.

Shown that FIG. **3** is a partial cross-sectional view of the main body **11** along the line **2-2** of FIG. **1**. Shown in FIG. **3** are three staggered insets **60** for receiving the nozzle assembly **40**. As can be seen in FIG. **3**, the insets **60** may actually be positioned on radial angles sufficiently small that in the perspective of FIG. **3** the insets **60** may be seen to overlap with each other. This facilitates a very close spacing of the angles of fluid jets from the nozzle assemblies **40** and increases the likelihood that high-pressure jet fluid flow will be directed at virtually every portion of the interior surface, perforation, slot or other opening of the casing. Further, the individual insets **60** can be "clocked" respectively between the arrays of nozzles such as is shown in **18**A, **18**B and **18**C. Thus the individual nozzles of **18**B can be clocked a few degrees from the positioning of the nozzles of **18**A and the nozzles of **18**C can be clocked a few degrees from the positioning of the nozzles of **18**B. In this fashion a very comprehensive coverage of the interior surfaces of the casing, perforations, slots or other openings can be achieved by the directed jets of fluids exiting the nozzles.

During operation, in some embodiments, the main body **11** can be raised and lowered once or multiple times through the entire production zone of the well. In such fashion, the individual brushes and nozzles are effective through the entire production zone.

In some embodiments a tubular type filter can be positioned at the top of the assembly **10** and inside the work string attached to the assembly **10**. The filter can provide many benefits including ensuring that only desired qualities of fluids (i.e. fluids without undesirable particles) are pumped into the assembly **10** and out the individual nozzles **40**. The tubular configuration of the filter can facilitate a modular array of filters that are connected end to end above the assembly **10**. In this fashion an overabundance of filter modules can be provided in conjunction with the assembly **10** before it is lowered into the well. The overabundance of filter capability can be useful to prevent a circumstance where a deficiency in filter surface area might exist while the tool **10** is down in the casing in cleaning operation. Should the filter have insufficient surface area to handle filtering needs for the entire duration of the cleaning operation, the filter may collapse because of the high pressures or otherwise become clogged thus reducing the efficacy of the cleaning operation. In some embodiments, the filter assemblies may comprise a 40 micron stainless steel strainer positioned at some distance, such as 30 feet, above the assembly **10** and a 30 micron stainless steel strainer located directly over the assembly **10**.

In some embodiments, the inset portion for receiving the fiber assembly holder **26** of the individual brush assemblies **22** may be designed to snugly receive the fiber assembly holder **26**. By this fashion additional mechanical support and directive force is applied to the brush portions of the individual brushes.

In some embodiments the assembly **10** can be configured and the system operated so as to provide up to 2000 or more pounds of fluid pressure per individual nozzle.

Some embodiments of the present systems and devices can be applied to improve production from liner completed wells, inner liner completed wells, and solid string completed wells.

In some embodiments a surface pump is used to displace fluids at high pressures through a working string to the assembly **10**. In some embodiments the assembly **10** may also comprise an upper collar that acts as a centralizer for the apparatus while in the casing. In some embodiments the assembly **10** may comprise a lower collar that acts as a centralizer for the apparatus while in the casing. In some embodiments the apparatus **10** may include both an upper and a lower collar. In some embodiments a scraper may be attached to the lower portion of the assembly **10**. The collars may also allow the washing fluid to be evenly displaced.

In some embodiments the O-ring used in the nozzle assembly seating system may comprise Viton. In some embodiments the hexagonal or octagonal portion of the nozzle assembly **40** may facilitate set torque specifications for attaching the nozzle assemblies to the main body **11** and prohibiting undesirable loosening of the nozzles or over tightening of the nozzles. In some embodiments two or more circumferences of brush assemblies may be provided on the main body **11**.

In some embodiments the fluid pumped through the assembly **12** may comprise an acidic solution. In some embodiments the fluid may comprise a washing fluid. In some embodiments the fluid may comprise water as found in the region of the well site.

In some embodiments the individual nozzle assemblies **40** may extend radially outside the surface of the main body **11**. In some embodiments the individual nozzles assemblies **40** may extend just to the exterior surface of the main body **11**. In some embodiments the individual nozzle assemblies may not extend out to the exterior surface of the main body **11**. In some embodiments the nozzle assemblies **40** may be movably mounted on the main body **11**. In one embodiment, the nozzle assemblies are seeded into receivers in the main body. The nozzle assembly is connected to a piston type seat which is positioned in an inset in the main body. During operation when the assembly **10** is positioned in the production zone of the casing and the high-pressure fluid pumping is initiated, the pressure from the high-pressure fluid presses the piston assembly radially outward pressing the nozzles also radially outward and closer to the inside surface of the casing. In some embodiments the brush assemblies may also be movably positioned with piston type assemblies attached to the individual brushes. Again, when high-pressure fluid pumping is initiated the fluid pressure presses the piston assemblies and presses the brush assemblies radially outward and in enhanced contact with the inner surface of the casing. In some embodiments, the nozzle and or brush assembly configuration may include a spring which biases the positioning of the nozzle and or the individual brushes radially inward in the assembly **10** and until high-pressure fluid pumping is initiated. With the initiation of the high-pressure pumping, the bias of the spring is overcome by the pressure of the fluid on the piston and the nozzle and or brush is pressed radially outward into an enhanced position vis-à-vis the interior surface of the casing. In some embodiments this movable configuration of brush assemblies prevents the premature engagement of the brush with the inner surface of the casing as the assembly **10** is lowered through the well casing to the production zone. In some embodiments lowering the assembly **10** with the brushes fully engaged on the inner surface of the casing down the length of the casing can serve to both press undesirable amounts of debris or other materials into the production zone of the well (from upper portions of the well) and or undesirably wear out or bend the individual fibers of the brushes before the tool is actually positioned in the production zone of the well. In such an instance the scouring action of the brushes is diminished before the brushes reach the production zone of the well.

As previously mentioned, the main body **11** may have an inset portion for receiving the fiber assembly holder **26** of the individual brush assembly **22**. FIG. **4** shows a side view of an assembly **80** in accordance with embodiments of the present invention and FIGS. **5**A-**5**D and **6** show cross-sectional views of the assembly **80**. As shown in FIG. **6**, which is a detailed view of a portion of FIG. **5**A, a main body in the form of a hollow tube **82** has a recess or inset portion **84** that is formed into the outer circumferential surface **86** of the hollow tube. The inset portion **84** includes a first counter bore **88** having a first diameter **90**. The bottom surface **91** at the base of the first counter bore **88** provides a flat contact surface area that frictionally engages a brush assembly **110**. A holder portion **112** of the brush assembly **110** includes outer walls **114** that radius or bend inward at a radiused portion **116**. The radiused portion **116** surrounds a planar or flat portion **118**. When assembled, the flat portion **118** is pressed tightly against the bottom surface **91** at the base of the first counter bore **88**.

At the base of the first counter bore **88**, there is a second counter bore **92** that extends further toward the center of the tube **82**. The second counter bore **92** has a second diameter **94** that is smaller than first diameter **90** of the first counter bore **88**. At the base of the first counter bore **92**, there is a threaded through hole **93** that extends to the hollow portion **96** at the center of the tube **82**. The first counter bore **88**, second counter bore **82**, and threaded hole **93** are concentric with each other. The threaded hole is adapted to receive an externally threaded portion **120** of the brush assembly **110**. A circular boss **122** is located at the interface between the flat portion **118** and the threaded portion **120** of the brush assembly **110**.

In some embodiments, the threaded portion **120** is the body of a screw or bolt that is removable from the holder portion **112** of the brush assembly **110**. As explained below, a removable bolt would allow the brush assembly **110** to be easily mounted at preselected torque and removed for replacement due to wear. The threaded body of the removable bolt extends through a bore formed through the flat portion **118** and the boss **122**. During assembly, the holder portion **112** may be seated into the inset portion **84** of the tube **82** without the bolt. The boss **122**, being fixedly secured to the flat portion **118**, provides a piloting function when fitting within the second counter bore **92**. The piloting function centers or aligns the bore in holder portion **112** with the threaded through hole **93** in the tube **82**. In this manner, the removable threaded body **120** of the bolt can be inserted through the bore and into the threaded hole **93**. The head **121** of the bolt is held on the other side of the flat portion **118** and is tightened to a preselected torque level to ensure sufficient fictional contact between the flat portion **118** and bottom surface **91** of the first counter bore **88**. The area of the brush assembly **110** which surrounds the head **121** of the bolt may be free of bristles to allow access to the head **121** for tightening and removal of the bolt.

In some embodiments, the removable bolt is a 5/16"-18 hex head bolt and the threaded hole **93** is tapped to receive the 5/16"-18 thread of the bolt. Applicant has found that a 5/16" diameter for the threaded portion **120** provides sufficient combination of strength that prevents the brush assembly **110** from being sheared or broken off the tube **82** during cleaning operations in a well casing and sufficient thread engagement to prevent loosening.

In some embodiments, the first counter bore **88** has a depth **98** from the outer surface **86** that is at or about 0.375 inches, and the first diameter is at or about 1.375 inches. The depth **98** may be carefully selected so that bristles of a brush assembly extend radially outward beyond the outer surface **86** of the hollow tube **82** so as to make the overall outer diameter of the assembly **80**, measured from the tips of the bristles, greater than an inner diameter of the well casing or lining that is to be cleaned. In some embodiments, the bristles are of varying height and the overall outer diameter is measured from bristle tips that account for about 85% to 95% of the bristles. In some embodiments, the overall diameter as measured from 85% to 95% of the bristle tips is about 0.1 inches greater than the inner diameter (I.D.) of the casing to be cleaned. Applicant has found that having the overall diameter of the assembly **80** being 0.1 inch oversized relative to the well casing I.D. provides optimal cleaning results in many cases. In some embodiments, where the I.D. of the casing to be cleaned is about 5.5 inches, the overall diameter of the assembly **80** as measured from 85% to 95% of the bristle tips is at or about 5.6 inches. It will be appreciated that over sizing to a greater or lesser amount may be implemented as desired depending on the application, such as type of well, ground conditions, and other factors.

In some embodiments, the second counter bore **92** has a depth **100** from the base of the first counter bore **88** that is at or about 0.15 inches. In some embodiments, the depth **100** may be selected so that the boss **122** on the holder portion **112** of the brush assembly **110** does not bottom out or make contact with the bottom surface at the base of the second counter bore **92**. That is, the depth **100** is selected to allow for a small gap to remain between boss **122** and the bottom surface of the second counter bore **92**. In this manner, as the threaded portion **120** is tightened into the threaded hole **93**, the flat surface **118** of the brush assembly **110** is free to press down completely and engage the bottom surface **91** of the first counter bore **88** so as to prevent the brush assembly **110** from rotating and becoming dislodged during cleaning operations in the well casing.

In some embodiments, as shown in FIG. **4**, the inset portions **84** are spaced axially apart along the length of the tube **82**. In the illustrated embodiment, the tube **82** includes sixteen inset portions **84** in which are mounted a corresponding number of brush assemblies **110**. At each axial position, there are two inset portions **84** facing at opposite directions. The two opposite facing inset portions **84** lie on the same plane that is oriented perpendicular or substantially perpendicular to the central axis **130** of the tube **82**. In the illustrated embodiment, there are a total of eight such planes each having two opposite facing inset portions **84**. FIGS. **5**A-**5**D show the cross-section at four of those planes.

As shown in FIGS. **4** and **5**A-**5**D, the pairs of inset portions **84** are oriented at various angular positions in a double helical pattern. Each pair of inset portions **84** is clocked or angularly offset by forty-five degrees from adjacent pairs of inset portions **84**. In FIG. **5**A, with the 12 o'clock position designated at 0 degrees, the two inset portions **84** at plane **142** (FIG. **4**) may be described as being located at a 0-degree and a 180-degree position. In FIG. **5**B, the two inset portions **84** at plane **144** (FIG. **4**) may be described as being located a 45-degree position and a 225-degree position. In FIG. **5**C, the two inset portions **84** at plane **146** (FIG. **4**) maybe described as being located at a 90-degree position and a 270-degree position. In FIG. **5**D, the two inset portions **84** at plane **148** (FIG. **4**) may be described as being located at a 135-degree position and a 315-degree position. Thus it will be appreciated that every adjacent grouping of eight inset portions **84** encompasses a 360-degree cleaning coverage of a well casing in which an inset portion is located every 45 degrees. As shown in FIG. **4**, the inset portions **84** overlap each other in the circumferential direction, as indicated for example by area **132**, thus providing for complete 360-degree cleaning coverage when brush assemblies **110** are mounted in each inset portion **84**.

Applicant has found that with a well casing having an inside diameter of about 5 inches, optimal cleaning can be achieved with eight 1.4-inch diameter brush assemblies for every 360 degrees of cleaning coverage. In the illustrated embodiment of FIG. **4**, there would be sixteen brush assemblies **110** installed, providing 720 degrees of cleaning coverage. That is, there are sixteen brush assemblies for an internal well casing circumference of seventeen inches, or about one brush for every 1.1 inches of internal circumference of a well casing. Thus, it will be appreciated that a greater or less number of inset portions **84** and corresponding brush assemblies **110** may be implemented to allow for 360-degree cleaning coverage, depending on the internal circumference of the well casing to be cleaned. In other embodiments, there is one brush assembly for every 1.2 to 2 inches of well casing internal circumference. In other embodiments, there is one brush assembly for every 0.5 to 1 inches of well casing internal circumference.

Referring again to FIG. **4**, the planes on which the pairs of inset portions **84** are located are axially spaced apart. As previously mentioned, the planes are oriented perpendicular or substantially perpendicular to the central axis **130** of the tube **82**. In some embodiments, the axial spacing between the planes is selected to prevent removed material, such as paraffin, wax, scale, or other residue on the inside of the casing of the well, from building up and gathering around the bristles of the brush assemblies **110** to an extent inhibits cleaning. In some embodiments, the axial spacing provides a helical or spiral channel between the brush assemblies **110** to allow the removed material and cleaning fluid to move away from the assembly **80** while in the well casing, thereby allowing for continuous high pressure flow of cleaning fluid.

In some embodiments, a first plane **140** is located at an axial distance of about 3.38 inches from a first edge **83** of the tube **82**. The previously mentioned second plane **142** is located at an axial distance of about 6.44 inches from the first edge **83**. FIG. **5**A shows the cross-sectional view through the second plane **142**. The previously mentioned third plane **144** is located at an axial distance of about 8.14 inches from the first edge **83**. FIG. **5**B shows the cross-sectional view through the third plane **144**. The previously mentioned fourth plane **146** is located at an axial distance of about 9.84 inches from the first edge **83**. FIG. **5**C shows the cross-sectional view through the fourth plane **146**. The previously mentioned fifth plane **148** is located at an axial distance of about 12.9 inches from the first edge **83**. FIG. **5**D shows the cross-sectional view through the fifth plane **148**. A sixth plane **150** is located at an axial distance of about 14.6 inches from the first edge **83**. A seventh plane **152** is located at an axial distance of about 16.3 inches from the first edge **83**. An eighth plane **154** is located at an axial distance of about 19.4 inches from the first edge **83**.

Still referring to FIG. **4**, the tube **82** includes a plurality of holes **160** which provide outlets for cleaning fluid flowing through the central passage **96** of the tube **82**. The outlet holes **160** are arranged in series along several circumferential ring patterns on the outer surface **86** of the tube **82**. Each circumferential pattern or ring lies on an outlet plane oriented perpendicular or substantially perpendicular to the central axis **130** of the tube **82**.

In the illustrated embodiment of FIG. **4**, the outlet holes **160** are concentrated in three jetting zones **184**A, B, C, each of the zones comprising twelve outlet holes **160**. The twelve outlet holes **160** are centered on a pair of outlet planes that oriented perpendicular or substantially perpendicular to the central axis **130** of the tube **82**. One of these outlet planes is designated as line **7-7** in FIG. **4** and a cross-sectional view at this plane is shown in FIG. **7**. Each outlet plane includes six outlet holes **160**. The pair of outlet planes are spaced apart axially. The axial spacing between the outlet planes (i.e., the axial spacing between outlet holes **160**) may be selected as a balance between, on one hand, maintaining sufficient strength and structural integrity of the tube **82**, and on the other hand, maximizing the number of outlet holes **160** to provide cleaning coverage of the well casing circumference. In the illustrated embodiment, the axial spacing between planes of each pair is at or about 0.4 inches. Further, each jetting zone **184**A, B, C is axially spaced apart from an adjacent jetting zone. The axial spacing between each jetting zone **184**A, B, C may be selected as a balance between, on one hand, maximizing fluid flow out of each jetting zone without inhibiting or significantly affecting fluid flow from an adjacent jetting zone, and on the other hand, minimizing the overall axial length of the assembly **80**. In the illustrated embodiment, the first jetting zone **184**A is at least about 6 inches from the second jetting zone **184**B, which is about 6 inches from the third jetting zone **184**C.

As shown in FIG. **7**, each outlet plane includes six outlet holes **160**. The outlet holes **160** are equally spaced apart from each other by about 30 degrees. For a well casing having an internal diameter of about 5.5 inches, there are six outlet holes **160** distributed around an internal well casing circumference of 17 inches. That is, for each outlet plane, there is one outlet hole for about every 3 inches of internal well casing circumference. As previously mentioned each jetting zone **184**A, B, C includes two outlet planes. As shown in FIG. **8**, the outlet holes **160** of one outlet plane (illustrated with solid lines) are clocked or offset by 30 degrees from the outlet holes **160** of the immediately adjacent outlet plane (illustrated with broken lines). Thus, each jetting zone, which includes two outlet planes, provides twelve outlet holes **160** distributed around an internal well casing circumference of 17 inches. That is, for each jetting zone **184**A, B, C, there is one outlet hole for about every 1.4 inches of internal well casing circumference. It will be appreciated that a greater or less number of outlet holes **160** may be implemented depending on the internal circumference of the well casing to be cleaned. In some embodiments, there is one outlet hole **160** for about every 0.7 to 1.3 inches of internal well casing circumference. In some embodiments, there is one outlet hole **160** for about every 1.5 to 2 inches of internal well casing circumference.

In some embodiments the outlet holes **160** and nozzles **170** in one jetting zone is clocked or offset at a preselected angle from the outlet holes **160** and nozzles **170** of adjacent jetting zones. FIG. **8** shows the angular positions of the outlet holes **160** and nozzles **170** for one of the jetting zones **184**C. For the adjacent jetting zone **184**B, the angular positions of the outlet holes **160** and nozzles **170** can be clocked or offset by an angle of about 10 degrees from what is shown in FIG. **8**. For the third jetting zone **184**A, the angular positions of the outlet holes **160** and nozzles **170** can be clocked or offset by an angle of about 20 degrees from what is shown in FIG. **8**. In this manner, the entire assembly **80** provides a high pressure jet of cleaning fluid at every 10 degree position. For a well casing having an I.D. of 5.5 inches, there would be 36 nozzles **170** for every 17.3 inches of well casing internal circumference. That is, for the entire assembly **80**, there is one nozzle for about every 0.5 inches of well casing internal circumference. In some embodiments, the entire assembly **80** provides one nozzle **170** for every 0.1 to 0.4 inches of well casing internal circumference. In some embodiments, the entire assembly **80** provides one nozzle **170** for every 0.6 to 1 inch of well casing internal circumference.

Referring again to FIG. **8**, each outlet hole **160** includes a counter bore **162** and an internally threaded hole **164** that extends from the base of the counter bore to the hollow portion or central fluid passageway **96** of the tube **82**. The outlet hole **160** is shaped to receive a nozzle **170**, shown in FIGS. **9**A-D. The counter bore **162** is sized to receive a nozzle outlet portion **172** and the threaded hole **164** is configured to engage an externally threaded portion **174** of the nozzle **170**.

In some embodiments, the counter bore **162** has a depth **166** that may be selected such that an outermost tip of the nozzle outlet portion **172** extends radially outward and away from the outer surface **86** of the tube **82** by a distance of about 0.25 inches, leaving a gap of about 0.5 inches between the nozzle tip and the interior surface of a well casing to be cleaned. It will be appreciated that the nozzle tip may protrude outward at lesser or greater distances.

In some embodiments, as shown in FIG. **9**A-D, the nozzle **170** has the shape of a hexagon-head bolt with side walls that can be engaged by a torque wrench or other tool to allow for installation and removal of the nozzle for cleaning and replacement. In some embodiments, the nozzle **170** is about one inch in length, with the nozzle outlet portion **172** and the threaded portion **174** being about 0.5 inches each in length. The side walls **176** of the hexagon-shaped outlet portion **172** may have a wall-to-wall distance **178** of about 0.5 inches and a point-to-point distance **180** of about 0.6 inches, which allows rotation of the outlet portion **172** within a 0.625-inch diameter of the counter bore **162** of the outlet holes **160**. A fluid passageway **182** formed through the nozzle **170** tapers down in three segments: an inlet segment **184** having a first diameter, an outlet segment **186** having a second diameter smaller than the first diameter, and a constriction or tapered segment **188** disposed between the inlet and outlet segments and providing a transition from the first diameter to the second diameter. The tapering down or narrowing of the fluid passageway **182** facilitates high pressure flow of cleaning fluid out toward the well casing. The second diameter may be selected to maintain a balance between, on one hand, having sufficient clean fluid flow volume and pressure, and on the other hand, maintaining strength and structural integrity of the threaded portion **174** to prevent the nozzle outlet portion **172** from shearing off the tube **82** during cleaning operations inside the well casing. In some embodiments the first diameter is about 5/64 inch and the second diameter is about 1/8 inch and 0.6 inches deep. In some embodiments, the threaded portion **174** has a 1/4"-20 NC thread and the threaded hole **164** (FIG. **8**) in the tube **82** is tapped to a corresponding thread configuration.

As shown in FIGS. **9**C and **9**D, the outlet portion **172** of the nozzle **170** includes an annular groove **190** configured to receive a resilient O-ring seal when in an undeformed or natural state. The annular groove **190** may be sized to allow the entire O-ring to fit inside of it. In some embodiments, the depth **192** of the groove may be selected to be less than the thickness of the O-ring, and the inner and outer diameters of the groove may be selected to allow space for the O-ring to radially expand. During installation of the nozzle **170** in one of the outlet holes **160** in the tube **82**, the O-ring is placed in the annular groove **190** and a tool is used to engage the side walls **176** of the outlet portion **172** and rotate the nozzle **170** to a preselected torque at which the base of the head portion contacts the bottom of the counter bore **162** (FIG. **8**) of the outlet hole **160**. At the preselected torque level, the O-ring is squeezed due to the relatively shallow depth **192** of the annular groove **190**. As the o-ring is squeezed, it may expand to fill the space within the annular groove **190**, thereby creating a fluid tight seal. In some embodiments, the O-ring has a thickness of about 0.07 inches, an inner diameter of about 0.24 inches, and an outer diameter of about 0.38 inches. In some embodiments, the annular groove has a depth **192** of about 0.055 inches, an inner diameter of about 0.25 inches and an outer diameter of about 0.41 inches.

In some embodiments, as shown in FIGS. **10**A-I0C, a brush assembly **110'** may be retractable or capable of piston-like movement. In operation, while the assembly **80** is being lowered to the desired production area that requires cleaning, the brush assembly **110'** is in a retracted position as shown in FIGS. **10**A and **10**C, thereby avoiding undue wear and degradation of the bristles before the assembly **80** reaches the area to be cleaned, which may be several hundred to thousands of feet below the well surface. When cleaning fluid is introduced into the central fluid passageway **96**, pressure from the fluid may force the brush assembly **110'** radially outward to an extended position (FIGS. **10**B and **10**D), away from the center of the tube **82**, thereby pressing the bristles of the brush assembly against the inner surface of the well casing to be cleaned.

Retraction may be accomplished using a piston-type assembly that includes inserts **200** that are bolted to the body of the tube **82**. Sealing elements **202**, such as O-rings, may be used between sliding surfaces of the insert and the stem **120'** of the brush assembly **110'**. The stem **120'** may include a locking element **204** that limits the radially outward movement of the brush assembly.

In other embodiments, as shown in FIG. **10**C, the retractable brush assembly **110'** may be biased to be in the retracted position by a spring **210** disposed between the locking element **204** and the inserts **200**. In this fashion, the brush assembly **110'** remains in the retracted position until a threshold level of fluid pressure is present in the central fluid passageway **96**.

In some embodiments, as shown in FIG. **10**D, the retractable brush assembly **110'** may be biased to be in the extended position by a spring **220** disposed between the inserts **200** and the bottom, flat surface **118'** of the holder portion of the brush assembly **110'**. In this fashion, the brush assembly **110'** may retract when it reaches a bend or turn in the well casing, thereby allowing the cleaning assembly tool **80** to pass the bend and reach the area of the well casing that requires cleaning.

In some embodiments, as shown in FIGS. **11**A-**11**D, nozzles **170'** may be retractable or capable of piston-like movement. In operation, while the assembly **80** is being lowered to the desired production area that requires cleaning, each nozzle **170'** is in a retracted position as shown in FIGS. **11**A and **11**C, thereby avoiding possible damage before the assembly **80** reaches the area to be cleaned. When cleaning fluid is introduced into the central fluid passageway **96**, pressure from the fluid may force the nozzles **170'** radially outward to an extended position (FIGS. **11**B and **11**D), away from the center of the tube **82**, thereby bringing high pressure jets of cleaning fluid closer to the inner surface of the well casing to be cleaned.

Retraction may be accomplished using a piston-type assembly that includes inserts **200'** that are bolted to the body of the tube **82**. Sealing elements **202'**, such as O-rings, may be used between sliding surfaces of the inserts **200'** and the stem **174'** of the nozzle **170'**.

The stem **174'** may include a locking element **204'** that limits the radially outward movement of the nozzle.

In other embodiments, as shown in FIG. **11**C, the retractable nozzle **170'** may be biased to be in the retracted position by a spring **210'** disposed between the locking element **204'** and the inserts **200'**. In this fashion, the nozzle **170'** remains in the retracted position until a threshold level of fluid pressure is present in the central fluid passageway **96**.

In some embodiments, as shown in FIG. **11**D, the retractable nozzle **170'** may be biased to be in the extended position by a spring **220'** disposed between the inserts **200'** and the bottom of the head portion **172'** of the nozzle **170'**. In this fashion, the brush assembly **110'** may retract when it reaches a bend in the well casing, thereby allowing the cleaning assembly tool **80** to pass the bend and reach the area of the well casing that requires cleaning.

A system **300** for improving pumping operations in accordance with embodiments of the present invention is shown in FIGS. **12** and **13**. FIG. **12** shows the system **300** disassembled, and FIG. **13** shows the system **300** partially assembled. The system **300** comprises a hollow scratcher tube **302** having a plurality of outlet holes for holding high pressure nozzles and a plurality of inset portions for holding brush assemblies. The scratcher tube **302** is externally threaded at a bottom end **301** to allow it to be connected to another tool, such as a scraper, or to allow it to be capped off with an end cap. The scratcher tube **302** is also externally threaded at an inlet end **303** to allow it to be connected to a base sub **304**. A standard coupler **306** with internal threads at both ends may be used to connect the scratcher tube **302** to the base sub **304**.

The base sub **302** is a hollow tube and includes external threads and internal threads at its inlet end **305**. The external threads allow the base sub **304** to be connected to a working string **310**. The working string **310** is a hollow tube which is used to lower the scratcher tube **302** to the region of a well casing that is to be cleaned and is used to deliver cleaning fluid to the scratcher tube. Another standard coupler **306** may be used to connect the inlet end **305** of the base sub **304** to the working string **310**. The internal threads at the inlet end **305** of the base sub **304** allow the base sub **304** to be connected to a tubular filter **308**. The tubular filter **308** is hollow includes cylindrical walls made of fine stainless steel mesh. Cleaning fluid delivered down the working string **310** passes through the mesh of the cylindrical walls and exits through an outlet end **309** which is in fluid communication with the internal fluid passageway of the scratcher tube **302**. The outlet end **309**, which is internally threaded, is connected to the inlet end **305** of the base sub **304**. This connection may be accomplished using a stainless steel pipe **312** that is externally threaded at both ends. When assembled, as shown in FIG. **13**, the filter **308** is located inside of the working string **310**. The filter **308** is sized so that there is a gap or space between its cylindrical walls and the internal circumference of the working string **310**. In this manner, cleaning fluid delivered down into the working string **310** may easily pass into the filter **308**. The top end of the filter **308** may be covered by an end cap, or may be connected to another filter to allow for greater filtering capacity in order to support delivery of higher volumes of cleaning fluid to the scratcher tube **302**.

In some embodiments, the system **300** may include a pressure valve disposed above the scratcher tube **302** and configured to limit or prevent delivery of fluid to the scratcher tube **302** unless a predetermined fluid pressure, referred to as an opening threshold pressure, is present in the working string **310**. The pressure valve may include a valve element that is biased to a closed position by a spring that pushes the valve element at a force level that corresponds to the opening threshold pressure. In some embodiments, the pressure valve is located within the base sub **304**. In some embodiments, the pressure valve is located within the pipe **312** between the base sub **304** and the filter **308**. By controlling the fluid pressure in the working string **310**, cleaning fluid may be prevented from flowing out of the scratcher tube **302** while the scratcher tube **302** is being lowered into the well casing before reaching the region to be cleaned. In this manner, the amount of cleaning fluid that is wasted can be reduced. Also, the quantity of cleaning fluid that enters the geological formation can also be minimized if desired.

In some embodiments, the system **300** may include a choke device that limits or prevents delivery of fluid to the scratcher tube **302** when the fluid pressure inside the working string **310** is excessive. In this way, damage to nozzles and any piston-type assemblies on the scratcher tube **302** due to a sudden pressure shock may be avoided.

As shown in FIG. **12**, the outlet holes and inset portions on the scratcher tube **302** may be positioned at a distance from the threaded ends that is sufficient to allow holding and turning tools, such as tongs, to engage the scratcher tube and facilitate assembly. The distance may from one to three inches.

During the operation of system **300**, significant damage can occur to the brush assemblies of scratcher tube **302**. FIGS. **14** and **15** illustrate one or more examples of embodiments of a system **1400** for improving pumping operations. System **1400** can also be considered a system for improving pumping operations with improved protection for brush assemblies. FIG. **14** shows system **1400** disassembled, and FIG. **15** shows system **1400** partially assembled.

System **1400** can be considered similar to system **300** of FIGS. **12** and **13**. For example, system **1400**, like system **300**, can comprise a scratcher tube **302**, one or more couples **306**, a base sub§, a stainless steel pipe **312**, a tubular filter **308**, an end cap, and a working string **310**. In addition, system **1400** can comprise one or more skid assemblies **400**. Furthermore, system **1400** can also comprise a guide piece **1416** with one or more skid assemblies **400**.

Skid assemblies **400** can assist system **1400** when system **1400** is placed and operating within a well casing. For example, skid assemblies **400** can help maintain system **1400**, and particular scratcher tube **302**, maintain a position that is relatively centrally located within a well casing. In addition, skid assemblies **400** can assist in protecting brush assemblies from becoming damaged during the operation of system **1400**.

As can be seen in FIG. **14**, system **1400** comprises a scratcher tube **302**. Scratcher tube can comprise inset portions **420** and outlet holes **425**. As previously discussed, outlet holes **425** can be used for holding high pressure nozzles. Similarly, inset portions **420** can be used to hold brush assemblies. In addition, inset portions **420** can be used to hold skid assemblies **400**. Skid assemblies **400** are described further with reference to FIG. **16**.

With continued reference to FIG. **14**, skid assemblies **400** can be used in any of the inset portions **420** on scratcher tube **302**. In some examples, there are at least three skid assemblies **400** positioned within inset portions **420**. If there are three skid assemblies **400** attached to scratcher tube **302**, each of the skid assemblies **400** may be separated from each other by approximately 120 degrees radially as an example.

In other examples, there may be four skid assemblies **400** attached to scratcher tube **302**. In such examples, each of the skid assemblies may be positioned approximately 90 degrees apart radially. For example, if there is a double helical pattern to the inset portions **420**, as previously discussed, two skid assemblies **400** can be positioned 180 degrees apart radially from one another. In some examples, these two skid assemblies can be positioned at the same distance latitudinally on scratcher tube **302**. In addition, the two other skid assemblies **400** can also be positioned 180 degrees radially from one another and at the same or different distance latitudinally on scratcher tube **302**. Furthermore, the second set of two skid assemblies can be positioned with a 90 degree offset radially from the first set of two skid assemblies. In such a setting, each skid assembly will be separated from the nearest radial skid assembly by approximately 90 degrees. It should be noted that less than three or more that four skid assemblies

400 can be positioned on scratcher tube 302. In addition, skid assemblies can be positioned at any radially separation that is desired.

FIG. 17 illustrates an example of a scratcher tube 300 removably coupled to brush assemblies 20 and skid assemblies 400 via inset portions of the scratcher tube 302, according to an embodiment. As can be seen in FIG. 17, there is a double helical pattern to the inset portions, which either comprise a brush assembly 20 or a skid assembly 400. In the example of FIG. 17, each skid assembly 400 is separated from the nearest radial skid assembly by approximately 90 degrees. In addition, each skid assembly 40 is radially separated from the nearest latitudinal skid assembly by 180 degrees.

In addition to having skid assemblies on scratcher tube 302, system 1400 may comprise skid assemblies 400 on guide piece 1416. Guide piece 1416 can comprise a hollow tube and can include external threads and internal threads that will allow the guide piece 1416 to couple with scratcher tube 302 and end cap 1420. Any number of skid assemblies 400 can be positioned on guide piece 1416. In addition, skid assemblies 400 on guide piece 1416 can be larger or smaller than those placed on scratcher tube 302. In some examples, skid assemblies 400 coupled to guide piece 1416 are the same size as skid assemblies 400 coupled to scratcher tube 302. In some example, skid assemblies 400 are uniformly radially positioned around guide piece 1416.

FIG. 20 illustrates an example of a cross-sectional view of guide piece 1416 with four skid assemblies 400 while system 1400 is in a well casing 2050. As can be seen in FIG. 20, the four skid assemblies 400 extend outwardly from guide piece 1416. This configuration helps minimize the displacement of system 1400 when in a well casing. As the guide piece 1416 moves laterally towards the walls of the well casing 2050, the skid assemblies 400 will collide with the wall, therefore minimizing the amount of lateral movement of system 1400 is well casing 2050.

Similarly, and with reference to FIG. 15, system 1400 may comprise skid assemblies 400 on base sub 1504. Once again any number of skid assemblies 400 can be positioned on base sub 1504. In addition, skid assemblies 400 on base sub 1504 can be larger or smaller than those placed on scratcher tube 302 and/or end cap 1416. In some examples, skid assemblies 400 coupled to base sub 1504 are the same size as skid assemblies 400 coupled to scratcher tube 302 and/or end cap 1416. In some example, skid assemblies 400 are uniformly radially positioned around base sub 1504.

It should be noted that system 1400 can include skid assemblies 400 on any combinations of the end cap 1416, the scratcher tube 302, and the sub base 1504. For example, only one of the end cap 1416, the scratcher tube 302, or the sub base 1504 can comprise skid assemblies 400. In other examples any two of the end cap 1416, the scratcher tube 302, and the sub base 1504 can comprise skid assemblies. In yet another example, all three of the end cap 1416, the scratcher tube 302, and the sub base 1504 can comprise skid assemblies 400.

In some embodiments, as shown in FIG. 16, the skid assembly 400 comprises a skid 402 and a fastening bolt 412 that attaches to inset portions 84 on the scratcher tube 82. The skid 402 can comprises a semi-spherical body 410 connected to a cylindrical base 408, which sits below the circumferential surface 86 of the hollow tube. The skid 402 can comprise two cylindrical cavities (a lower skid cavity 404 and an upper skid cavity 406) through the middle of the skid to accommodate the fastening bolt 412. It should be noted that the body 410 can comprise shapes other than semi-spherical. For example, the body 410 can be a portion of a sphere that is less than 50%. Other examples for the body shape can include: conical, cylindrical, pyramid, and the like. In addition, the skid body can comprise other shapes not specifically mentioned herein.

FIG. 18 shows an example of a top view of skid 402 according to one embodiment. As illustrated in the example of FIG. 18, lower skid cavity 404 can have a smaller radius than upper skid cavity 406.

In some embodiments the lower skid cavity 404 can have radius that is equal to or slightly larger than the radius of the thread of the fastening bolt 412. In the same or other embodiments the upper skid cavity 406 can have a radius that is equal to or slightly larger than the radius of the head of the fastening bolt 412. In some embodiments, the fastening bolt 412 is a 5/16"-18 hex head bolt and the threaded hole 93 is tapped to receive the 5/16"-18 thread of the bolt. The skid assembly threads into the inset portions 84, which may comprise: a main body in the form of a hollow tube 82 has a recess or inset portion 84 that is formed into the outer circumferential surface 86 of the hollow tube. The inset portion 84 includes a first counter bore 88 having a first diameter 90. The bottom surface 91 at the base of the first counter bore 88 provides a flat contact surface area that frictionally engages the skid 402.

In some embodiments the skid 402 comprises steel or aluminum. As an example, skid 402 can comprise stainless steel. In some embodiments the skid assembly 400 protrudes from the scratcher tube 82 less than the brush assemblies 110, but protrudes more than the holder portion 112 of the brush assembly 110. As an example, the brush assemblies can extend from approximately 0.100 to approximately 0.135 inches past the edge of well casing walls; and the skid assemblies can extend from approximately 0.100 to approximately 0.135 inches short of the same well casing walls. It should be noted that the brush assemblies can extend less than or more than 0.100 to 0.135 inches past the well casing. For example, the brush assemblies can extend from approximately 0.001 to approximately 0.135 inches past the well casing or from approximately 0.135 to approximately 0.25 inches past the well casing. Likewise, the skid assemblies can extend less than or more than 0.100 to 0.135 inches short of the well casing walls. For example, the skid assemblies can extend from approximately 0.001 to approximately 0.135 inches short of the well casing or from approximately 0.135 to approximately 0.25 inches short of the well casing. In other embodiments the brush assemblies can extend approximately 0.125 inches past the well casing and the skid assemblies can extend to approximately 0.125 inches short of the well casing.

With continued reference to FIG. 16, the creation of the upper skid plat cavity 406 can leave an open area at the top of skid 402, which is designated by the dotted line 407. This can create a sharp edge as seen in FIG. 16. In some embodiments, this sharp edge can be deburred. In other embodiments, a cap can be placed over the upper skid plat cavity 406. This cap can follow the path designated by dotted line 407. In yet other embodiments, a customized fastening bolt 412 can be used, which, when fully assembled, would have a top edge that follows the path designated by dotted line 407. In yet other embodiments, the sharp edges remain.

The skid assemblies 400 can be coupled to the guide piece 1416 and the base sub 1504 as described above in relation to scratcher tube 302. In addition, this configuration allows additional tools to be used instead of skid assemblies and/or brush assemblies. For example, it may be desirable to couple a scraper assembly to the inlet portions of the guide piece. The scraper assembly would function to scrape the walls of a well casing while system 1400 is in operation. In such examples, the scraper assemblies would be coupled to the guide piece in a fashion that is similar to how the skid assemblies and/or brush assemblies are coupled to the scratcher tube. Furthermore, in such an embodiment, the radius from the center of the guide piece to the outer edges of the scrapper assemblies can be nearly the length as the radius of the well casing.

In some embodiments, system **1400** comprises a system that can be used in a number of different environments. For example, system **1400** can be used in a number of different sized casings. As an example, guide piece **1416** can be used for operations of various sized well casings. Guide piece **1416** can be coupled to the other elements of system **1400** as described above. The same sized guide piece can be configured to attach to system **1400** using a universal sized threading. In addition, different sized skid assemblies **400** can be coupled to the guide piece **1416**. For larger casings, a larger skid assembly can be used, thereby causing the radius from the center of the guide piece the outer edge of the skid assembly to increase and be closer to the walls of the well casing.

In some embodiments, system **1400** can be used in well casings that bend. The configuration of system **1400**, with the addition of skid assemblies **400** allow system **1400** to maneuver turns in the casing more easily.

While particular embodiments of the invention and variations thereof have been described in detail, other modifications and methods will be apparent to those of skill in the art. Accordingly, it should be understood that various applications, modifications, and substitutions may be made of equivalents without departing from the spirit of the invention or the scope of the claims. Various terms have been used in the description to convey an understanding of the invention; it will be understood that the meaning of these various terms extends to common linguistic or grammatical variations or forms thereof. Further, it should be understood that the invention is not limited to the embodiments that have been set forth for purposes of exemplification, but is to be defined only by a fair reading of claims that will be appended, including the full range of equivalency to which each element thereof is entitled.

While several particular forms of the invention have been illustrated and described, it will also be apparent that various modifications can be made without departing from the scope of the invention. It is also contemplated that various combinations or subcombinations of the specific features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes of the invention. Accordingly, it is not intended that the invention be limited, except as by the appended claims.

What is claimed is:

1. A device for improving pumping operations through a casing or lining, the device comprising:

a hollow tube including a tube wall having an outer circumferential surface and an inner circumferential surface, the inner circumferential surface defining a fluid passageway;

brushes on the outer circumferential surface;

skids on the outer circumferential surface; and

outlet holes formed through the tube wall.

2. The device of claim **1**, wherein the brushes and the skid are arranged along a double helical pattern on the outer circumferential surface.

3. The device of claim **1**, wherein the outlet holes are arranged in a plurality of groups, each group forming a circular pattern around the outer circumferential opening.

4. The device of claim **1**, wherein the brushes include a plurality of brush assemblies, and at least one of the brush assemblies is removably attached to the tube wall.

5. The device of claim **1**, wherein at least one of the skids is removably attached to the tube wall.

6. The device of claim **1**, wherein the brushes and skids are seated in a recess formed into the outer circumferential surface of the tube wall.

7. The device of claim **1**, wherein the brushes and skids are interchangeable.

8. A system for improving pumping operations, comprising:

one or more brushes;

one or more skids;

one or more outlet holes;

a working string; and

a hollow tube

wherein:

the one or more brushes are coupled to the hollow tube; and

the hollow tube comprises at least a portion of the one or more outlet holes.

9. The system of claim **8**, wherein the at least a portion of the one or more skids are coupled to the hollow tube.

10. The system of claim **8**, further comprising a guide piece.

11. The system of claim **10**, wherein at least a portion of the one or more skids are coupled to the guide piece.

12. The system of claim **11**, wherein a portion of the one or more skids are coupled to the hollow tube.

13. The system of claim **11**, wherein the guide piece is configured to be coupled to skids of multiple sizes.

14. The system of claim **13**, wherein the guide piece is capable of being used in a plurality of well casings of different radii.

15. An apparatus for protecting brushes on a device for improving pumping operations, comprising:

a base;

a body;

and a fastening bolt;

wherein:

the base is cylindrical; and

the body comprises a shape that is a portion of a sphere.

16. The apparatus of claim **15**, further comprising:

an upper cavity and a lower cavity;

wherein the upper cavity has a radius that is greater that the lower cavity.

17. The apparatus of claim **15**, wherein:

the fastening bolt is configured to be coupled to a hollow tube for use in improving pumping operations.

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